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Modelling International Trade in Art – Modified Gravity Approach

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Abstract

The issue of modelling international trade in works of art has been taken up in the paper. It presents the gravity approach to the international trade in art in European Community countries. The analysis is based on Eurostat international trade data (Harmonised System for export and import chapter 97 – works of art, collectors' pieces and antiques, including respective kinds of works of art: paintings, drawings and pastels; collages, graphic arts, sculptures and antiques). The gravity model is based on nonlinear (power function) regression made in *Statistica 9.0* software. It should be underlined that instead of GDP, traditionally used in gravity models of international trade, author proposes to use art markets' turnovers on internal markets as independent variables. Using the mentioned model the author explains the influence of art markets of considered countries and distances between them on total export and import of work of art.

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Keywords: international trade model; international trade in art; gravity model; gravity in international trade; art trade; art market

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1. Introduction

Gravity models used in analysis of socio-economic phenomena are derived from Newton's law of universal gravitation formulated on the grounds of physics in 1687 - gravity force active between two bodies is directly proportional to the product of masses of interacting bodies, and inversely proportional to the square of distance between their centres. Analogically, trade flows between two countries are directly proportional to economic "size" ("mass") of these countries, and inversely proportional to the square of distance between them. Reasoning *per analogiam*, the existence of identical regularities that govern behaviour of masses in gravitational field and interaction between objects (retail hubs, cities, urban agglomerations, regions, countries) in geographical space is assumed. Two basic forces that have an impact on the interaction of the masses have been taken from the Newton's prototype. On one hand, in gravity models, attraction forces acting between masses are considered by referring to the sizes of these masses, and, on the other, the distance between considered masses (centres in geographical space) is assumed as a repulsive force. Gravity theory in the field of social sciences has been used for regional analysis, transport analysis, analysis of phone calls, analysis of people's migration, analysis of trade between the hubs, and, finally, analysis of international trade, which will be the subject of this paper.

2. Literature review

Gravity models in international trade were for the first time used in the 1960s by Tinbergen and Pőyhőnen (Tinbergen 1962; Pőyhőnen 1963). Later, gravity models found its use in works of Linnemann and Anderson (Linnemann 1966; Anderson 1979). In the 1990s the issue of applying gravity models to international trade was taken up repeatedly (Bergstrandt 1985; Hamilton and Winters 1992; Frankel et al. 1995; Deardorff 1998; Evenett and Keller 1998; Endoh 1999; Brulhart and Kelly 1999]. Then, the issue of international trade in the context of gravity models appears in the works of: (Byers et al. 2000; Porojan 2001; Christie 2002; Baltagi et al. 2003; Martinez-Zaroso 2003; Anderson and van Wincoop 2003; Paas and Tafenau 2005; Fazzio et al. 2008; Xuegang et al. 2008; Helpman et al. 2008; Sichei et al. 2008; Fidrmuc 2009). The gravity models has also remained an important field of studies in recent years (Ghosh 2011; Bilici 2011; Kucharcukova et al. 2012; Kahane 2013; Cuenca Garcia et al. 2013; Gomez-Herrera 2013].

Presented in the first part of the paper, theoretical aspects of constructing gravity models for international trade flows will be the basis for creation of gravity model of international trade in a very special commodity of exchange – works of art. The goal of the paper is to find an answer to the question whether international trade in art can be described by means of gravity models, which have been successfully applied to international flow of other goods. Moreover, the possibility of modification of traditional gravity model of international trade will be presented.

3. Method of Research – Gravity Model

In gravity models, two basic forces, which influence interaction of masses, have been taken from Newton's prototype. On one hand, the models take into account forces acting between masses by referring to sizes of these masses, while on the other, variously defined distance between considered masses (centres in geographical space) is assumed as repulsion force. Among the types of distances the following may be listed: physical distance, communication distance, road distance, distance in time, transport cost, social distance, psychological distance. Positive impact on foreign trade is exerted by "mass" of the countries (measured for instance by means of GDP, GDP *per capita*), and negative impact – by the distance between them. Gravity approach requires verification with respect to works of art as objects of trade exchange between countries.

When referring to assumptions of gravity models, it needs to be reminded that gravity model of international trade defines bilateral streams of trade depending on broadly understood "masses", i.e. sizes of countries – partners of exchange and distance between them. This model adopts the following formula:

$$F_{ij} = G\frac{M_i M_j}{D_{ij}} \quad (1)$$

where:
F_{ij} - streams of international trade from country *i* to country *j* (export, import; alternative bilateral streams of international trade, i.e. the total of export and import),
G - constant,
M_i, M_j - masses of the countries, specifying "economic sizes" of the countries,
D_{ij} - distance between country *i* and country *j*.

Making selection of variables describing attraction and repulsion forces existing between countries remains an important issue while constructing gravitational models of foreign trade. Attraction force, i.e. "mass/size" of country is, as a rule, measured by means of GDP ratio, GDP ratio *per capita,* population figure, areas of countries – trade partners, production volume. Repulsion force that weakens gravity, from theoretical perspective, may take into account various types of restrictions of international trade. It may be understood in particular as geographical physical distance (in km, common border of two countries), temporal distance (travel time), economic distance (transport cost, trade policy, customs tariffs), political distance (membership in one of groups, participation in agreements of an international character) or cultural distance (e.g. linguistic distance).
Gravity model of international trade adopts the following general formula:

$$F_{ij} = P_i * P_j / D_{ij} \quad (2)$$

where:
F_{ij} – export or import or international exchange turnover,
P_i - GDP of country *i*,
P_j – GDP of country *j*,
D_{ij} – distance between country *i* and country *j,*
i, j – countries.
Assuming multiplicative interaction of independent variables, gravity model of international trade adopts the following formula:

$$F_{ij} = \beta_0 * P_i^{\beta 1} * P_j^{\beta 2} / D_{ij}^{\beta 3} \quad (i,j = 1,2,..., n;\ i \neq j) \quad (3)$$

where:
F_{ij} – export or import or international trade turnover,
P_i - GDP of country *i*,
P_j – GDP of country *j*,
D_{ij} – distance between country *i* and country *j,*
β_0, β_1,β_2, β_3 – model parameters,
i, j – countries,
n – number of spatial units (countries).

Gravity model of international trade in stochastic approach, as a power regression function, takes up the following formula:

$$F_{ij} = \beta_0 * P_i^{\beta 1} P_j^{\beta 2} D_{ij}^{\beta 3} e^{\varepsilon} \quad (4)$$

where:
ε – random component of the model
After linearizing transformation (logarithmizing), the model adopts the formula, which is subject to empirical testing,

i.e.:

$$\ln F_{ij} = \alpha + \beta_1 \ln(P_i) + \beta_2 \ln(P_j) + \beta_3 \ln D_{ij} + \varepsilon \quad (5)$$

where:
α – constant,
F_{ij} – export or import, or international trade turnover,
P_i - GDP of country *i*,
P_j – GDP of country *j*,
D_{ij} – distance between country *i* and country *j,*
β_1 β_2 β_3 – model parameters,
i, j – countries,
n – number of spatial units (countries),
ε – random component of the model

In gravity models of international trade, interactions within respective pairs of countries are analysed [Zeliaś, 1991; Suchecki, 2010]. From theoretical perspective, independent variables concerning the level of GDP of countries - *i* and *j* should be positively associated with international trade (export, import, international trade turnover) (β_1, β_2>0), whereas the distance should have negative impact on dependent variable (β_3 <0). Gravity models indicate that increasing distance by 1% results in a drop of trade volumes by 0.7% - 1% (Krugman, and Obstfeld 2007).

4. Gravity Models of International Trade in Art in the European Community Countries

In gravity models of international trade, GDP or GDP per capita are traditionally applied as a "mass" of a country, an equivalent of attracting gravity force. Taking up the issue of international trade in art while using gravity approach, a possibility to introduce other independent variable that specifies "mass" of a country to the gravity model is worth considering. In the paper turnover in art markets in respective countries will be assumed as a "mass" (independent variable) that has an impact on the sizes of international trade streams. According to the concept, countries with well-developed art markets should be characterized with higher turnovers of foreign trade in art, compared with countries, in which art markets are less developed. The model adopts the formula, which is subject to empirical testing:

$$\ln F_{ij} = \alpha + \beta_1 \ln(M_i) + \beta_2 \ln(M_j) + \beta_3 \ln D_{ij} + \varepsilon \quad (6)$$

where:
α – constant,
F_{ij} – export or import, or international trade turnover,
M_i - art market of country *i*,
M_j – art market of country *j*,
D_{ij} – distance between country *i* and country *j,*
β_1 β_2 β_3 – model parameters,
i, j – countries,
n – number of spatial units (countries),
ε – random component of the model

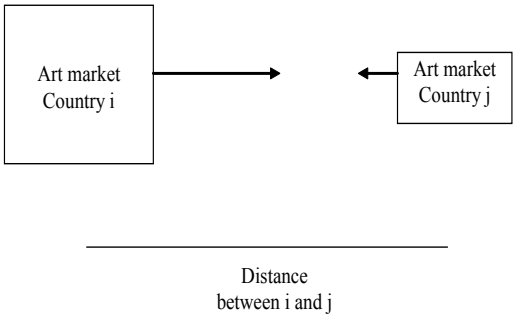

Fig.1. Interaction of art markets in a gravity model of international trade

In constructed gravity models of power regression, dependent variable is represented by export or import, or otherwise by turnovers of foreign trade (total export and import) in works of art between a pair of countries: *i* and *j*. Turnovers on art markets in countries *i* and *j,* as well as geographical distances between countries – partners of trade exchange, are independent variables. Data on export and import of works of art come from Eurostat database on international trade Comext Harmonised System for chapter 97 – works of art, collectors' pieces and antiques, including respective kinds of works of art: paintings, drawings and pastels; collages, graphic arts, sculptures and antiques). The data on art markets come from reports of European Fine Art Foundation TEFAF and European Fine Art Foundation, Kusin & Company. Data on distances between countries has been taken from CEPII data (fr. *Centre d'Etudes Prospectives et d'Informations Internationales*). The regression model has been made in *Statistica 9.0* software.

The obtained results of power regression analysis of international trade in art in the European Community countries in the years 2003, 2006, 2009 and 2012, on the basis of Equation 6, were listed in the Tables 1, 2, 3 and 4. As indicated in mentioned Tables 1-4, Beta coefficients for turnovers in art markets in countries *i* and *j* are positive, which means that the value of international trade in art for countries with higher development of art markets is higher as well. Beta coefficients for distances always adopt minus sign, indicating inverse correlation between distance and international trade in art (smaller distance between countries – partners of exchange favours higher international trade and the other way round – with the growing geographical distance between the countries, bilateral trade turnovers decrease). In the process of constructing regression models, verification of statistical significance of obtained models has been run (F-distribution - Fisher-Snedecor test) as well as verification of significance of received regression function parameters for respective variables (Student's t-test), at assumed level of significance $\alpha = 0.05$. Taking into account statistical significance of regression function parameters, the significance of received parameters for all independent variables considered in the model, i.e. turnovers in art markets of both countries and distance between them, must be indicated. In particular, based on gravity models of international trade in the works of art in the European Community countries, it might be stated that, first of all, there is statistically significant positive correlation between turnovers on art markets of countries – exchange partners and international trade in works of art, and secondly – there exists statistically significant negative correlation between distance from country *i* to country *j* and international trade in art. Countries with more developed art markets are characterized by higher value of international trade in works of art.

The assessment of obtained models of international trade in art in the European Community countries is presented in Table 5. Obtained results of the determination coefficients R^2 ranging between 0.40 and 0.60 prove that predictors considered in the model in 40% - 60% explain foreign trade in works of art. It should be emphasized that, during modelling process, removal of incongruous observations (pairs of countries) was necessary, and led

to improvement of the level of model adjustment to empirical data. Gravity models based on turnovers on art markets in the European Communities countries explain relatively large portion of foreign trade in art by means of mere three explanatory variables.

Comparing received models of international trade in the works of art, it is noteworthy that gravity models, in which dependent variable is represented by import or turnovers in international trade based on art markets, demonstrate better adjustment to empirical data as compared with models based on export of art. Particularly, for import as dependent variable, coefficient of determination R^2 ranges from 0.49 to 0.60, for foreign trade turnover from 0.54 to 0.59, while for export 0.39-0.51. Adjusted coefficient of determination R^2 for import as dependent variable ranges from 0.44 to 0.59, for foreign trade turnover from 0.52 to 0.58, while for export from 0.37 to 0.47.

Table 1. Gravity Models of International Trade in Works of Art in the European Community based on Art Markets of EC countries in 2003

Dependent variable	Independent variables	Beta	Standard error Beta	B	Standard error B	Student's t – test	P
Export	Absolute term			10.11452	2.764266	3.65902	0.000422
	Art market *i*	0.348760	0.081340	0.71170	0.165989	4.28766	0.000044
	Art market *j*	0.392019	0.082803	0.72916	0.154016	4.73433	0.000008
	Distance *ij*	-0.259603	0.083014	-0.99415	0.317900	-3.12724	0.002363
Import	Absolute term			10.08706	2.630068	3.83528	0.000232
	Art market *i*	0.450154	0.074697	0.80191	0.133067	6.02639	0.000000
	Art market *j*	0.430507	0.074823	0.83967	0.145936	5.75369	0.000000
	Distance *ij*	-0.312921	0.075330	-1.19310	0.287215	-4.15401	0.000074
Export + import	Absolute term			8.57208	2.623724	3.26714	0.001468
	Art market *i*	0.434620	0.067891	0.87688	0.136976	6.40170	0.000000
	Art market *j*	0.471630	0.069085	0.95197	0.139445	6.82684	0.000000
	Distance *ij*	-0.246658	0.070044	-1.01640	0.288632	-3.52145	0.000636

Variables measured in natural logarithms.
Source: author's own work based on Statistica 9.0 software.

Table 2. Gravity Models of International Trade in Works of Art in the the European Community based on Art Markets of EC countries in 2006

Dependent variable	Independent variables	Beta	Standard error Beta	B	Standard error B	Student's t – test	P
Export	Absolute term			12.50687	2.198455	5.68894	0.000000
	Art market *i*	0.471868	0.068938	0.67035	0.097934	6.84485	0.000000
	Art market *j*	0.292110	0.069371	0.41914	0.099538	4.21084	0.000049
	Distance *ij*	-0.287513	0.070648	-1.00820	0.247734	-4.06967	0.000084
Import	Absolute term			8.256699	2.218353	3.72199	0.000309
	Art market *i*	0.462288	0.067334	0.704812	0.102658	6.86562	0.000000
	Art market *j*	0.516914	0.067327	0.817818	0.106519	7.67766	0.000000
	Distance *ij*	-0.222682	0.067317	-0.824230	0.249166	-3.30796	0.001258
Export + import	Absolute term			12.53498	1.847439	6.78506	0.000000
	Art market *i*	0.532426	0.058743	0.73536	0.081134	9.06361	0.000000
	Art market *j*	0.353134	0.058651	0.50401	0.083710	6.02091	0.000000
	Distance *ij*	-0.302238	0.060089	-1.04587	0.207933	-5.02985	0.000002

Variables measured in natural logarithms.

Source: author's own work based on Statistica 9.0 software.

Table 3. Gravity Models of International Trade in Works of Art in the European Community based on Art Markets of EC countries in 2009

Dependent variable	Independent variables	Beta	Standard error Beta	B	Standard error B	Student's t – test	P
Export	Absolute term			9.03526	2.666306	3.38868	0.001040
	Art market *i*	0.492733	0.078562	0.94285	0.150329	6.27191	0.000000
	Art market *j*	0.406636	0.079249	0.72752	0.141786	5.13111	0.000002
	Distance *ij*	-0.249226	0.078537	-1,01238	0.319024	-3.17336	0.002056
Import	Absolute term			8.205662	2.221267	3.69414	0.000408
	Art market *i*	0.546667	0.073064	0.877407	0.117269	7.48202	0.000000
	Art market *j*	0.449814	0.073058	0.810391	0.131622	6.15698	0.000000
	Distance *ij*	-0.254689	0.073927	-0.838054	0.243256	-3.44516	0.000922
Export + import	Absolute term			14.09258	2.267838	6.21410	0.000000
	Art market *i*	0.474625	0.068736	0.85023	0.123130	6.90510	0.000000
	Art market *j*	0.374571	0.069073	0.66198	0.122072	5.42285	0.000000
	Distance *ij*	-0.391864	0.068738	-1.48698	0.260837	-5.70080	0.000000

Variables measured in natural logarithms.
Source: author's own work based on Statistica 9.0 software.

Table 4. Gravity Models of International Trade in Works of Art in the European Community based on Art Markets of EC countries in 2012

Dependent variable	Independent variables	Beta	Standard error Beta	B	Standard error B	Student's t – test	P
Export	Absolute term			22.46382	3.165059	7.09744	0.000000
	Art market *i*	0.494241	0.120656	1.08465	0.264787	4.09629	0.000227
	Art market *j*	0.306758	0.119448	0.66467	0.258816	2.56813	0.014520
	Distance *ij*	-0.346653	0.120557	-1.31286	0.456580	-2.87542	0.006736
Import	Absolute term			19.37127	2.943989	6.57994	0.000000
	Art market *i*	0.520756	0.121872	1.06838	0.250033	4.27296	0.000141
	Art market *j*	0.420425	0.120659	0.84014	0.241113	3.48442	0.001346
	Distance *ij*	-0.289240	0.127500	-1.23404	0.543978	-2.26854	0.029222
Export + import	Absolute term			22.52050	2.446189	9.20636	0.000000
	Art market *i*	0.513289	0.110339	0.95200	0.204647	4.65192	0.000043
	Art market *j*	0.372494	0.109235	0.68212	0.200032	3.41003	0.001616
	Distance *ij*	-0.364967	0.110249	-1.16816	0.352879	-3.31038	0.002125

Variables measured in natural logarithms.
Source: author's own work based on Statistica 9.0 software.

Table 5. Assessment of Models of International Trade in Works of Art based on Art Markets in the European Community countries in 2003-2012

	Model	R^2	Adjust. R^2	F	p	Standard estimation error
2003	Export	0.39466428	0.37492508	F(3,92)=19.994	p<0.00000	2.0922
	Import	0.53402808	0.51849568	F(3,90)=34.382	p<0.00000	1.8301
	Export + import	0.53966099	0.52650845	F(3,105)=41.031	p<0.00000	1.9194
2006	Export	0.46203826	0.44870036	F(3,121)=34.641	p<0.00000	1.7846
	Import	0.52258485	0.51002130	F(3,114)=41.595	p<0.00000	1.7065
	Export + import	0.59089068	0.58130218	F(3,128)=61.625	p<0.00000	1.5110
2009	Export	0.45043891	0.43232151	F(3,91)=24.862	p<0.00000	2.0359
	Import	0.60718666	0.59207845	F(3,78)=40.189	p<0.00000	1.4721
	Export + import	0.54957436	0.53592510	F(3,99)=40.264	p<0.00000	1.7388
2012	Export	0.51156872	0.47086611	F(3,36)=12.568	p<0.00001	1.6941
	Import	0.49065970	0.44821468	F(3,36)=11.560	p<0.00000	1.8114
	Export + import	0.59152482	0.55748522	F(3,36)=17.378	p<0.00000	1.3093

Source: author's own work based on Statistica 9.0 software

Conclusions

To recapitulate the considerations included in the paper, it must be stated that gravity theory of international trade, which has already been successfully applied to description of international trade in different goods and services, might also be used for such specific objects as works of art. The paper includes a new proposal for measuring "mass" of the country in the gravity model of international trade. Instead of traditionally used in these kinds of models GDP or GDP *per capita* the author proposes to introduce art markets' turnover on internal markets as independent variables i.e. attracting forces for international trade flows.

Presented in the paper power regression models are statistically significant and explain about 40% - 60% of international trade in art by means of three explanatory variables: art market of country i, art market of country j and distance between countries i and j. In particular, on the basis of gravity models of international trade in art in the European Comminity countries, it may be stated that there exists statistically significant positive correlation between art markets of countries and international trade in works of art and statistically significant negative correlation between the distance from country *i* to country *j* and international trade in art. Taking into account constructed gravity models of international trade in art, it must be pointed out that better models were achieved for total turnover of international trade in works of art than in the case of export and import of works of art treated separately.

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